DEPARTMENT OF THE ARMY
U. S. ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
U. S. ARMY BALLISTIC RESEARCH LABORATORY
ABERDEEN PROVING GROUND, MARYLAND 21005

DRDAR-TSB

27 October 1980

SUBJECT: Change of Distribution Statement

Commander
Defense Technical Info Center
ATTN: DDC-DDA
Cameron Station
Alexandria, VA 22314

A review of the reports listed below has been completed and it has been determined that the distribution limitation can be removed and the Statement "A" be applied:

REPORT	TITLE	DATE	AD NO
Memorandum Report No. 592	Body Nose Shaped For Obtaining High Static Stability.	Feb 52	802157
Memorandum Report No. 1112	The Aerodynamic Properties Of A Spike-Nosed Shell At Transonic Velocities.	Nov 57	156637

FOR THE COMMANDER:

Vernon J. Wyatt
VERNON J. WYATT
Chief
Technical Support Division

B A L L I S T I C   R E S E A R C H   L A B O R A T O R I E S

MEMORANDUM REPORT NO. 1112

NOVEMBER 1957

THE AERODYNAMIC PROPERTIES OF A SPIKE-NOSED SHELL AT TRANSONIC VELOCITIES

C. P. Sabin

Department of the Army Project No. 5B03-03-001
Ordnance Research and Development Project No. TB3-0108

A B E R D E E N   P R O V I N G   G R O U N D,   M A R Y L A N D

B A L L I S T I C   R E S E A R C H   L A B O R A T O R I E S

MEMORANDUM REPORT NO. 1112

CPSabin/bj
Aberdeen Proving Ground, Md.
November 1957

THE AERODYNAMIC PROPERTIES OF A SPIKE-NOSED SHELL AT TRANSONIC VELOCITIES

ABSTRACT

The aerodynamic characteristics of the 57-mm T188E18, a spike-nosed recoilless rifle HEAT shell which is designated to operate at transonic and high subsonic velocities, are presented and discussed.

From the considerable scatter in the aerodynamic data it is concluded that performance of spike-nosed shell at these velocities is inherently erratic although satisfactory for medium and short ranges.

TABLE OF SYMBOLS

CP_N	Location of center of pressure in calibers from base
K_D	Drag Coefficient = Drag/ρ u^2 d^2
K_{D_O}	Zero yaw drag coefficient
$K_{D_{\delta^2}}$	Yaw drag coefficient
K_M	Righting moment coefficient
K_N	Normal force coefficient
M	Mach number
$\overline{\delta^2}$	Mean Squared yaw
A	Axial moment of inertia
B	Transverse moment of inertia

INTRODUCTION

The 57mm T188E18 shell is a spike-nosed fin-stabilized HEAT round (Figure 1,2) designed for a muzzle velocity of 1200 ft/sec. Because of its availability and generally acceptable performance this shell was chosen as the model for free flight firings to furnish data on the aerodynamic characteristics at transonic speeds of shell of this general type*.

TEST PROGRAM

An extensive program, consisting of 46 rounds in all, was fired in the Transonic Range of the Free Flight Aerodynamics Branch[1]** to determine as accurately as possible the complete properties of the shell. The rounds were fired from an M18 recoilless rifle. The shell picked up a spin rate of approximately 1.5 to 2.0 degrees per foot due to friction with the rifling. Due to the absence of an obturator the shell was ejected from the muzzle enveloped in a cloud of powder gas. (see picture from Fastax movie taken at muzzle, Figure 18).

Mid-range Mach numbers for the test varied between 1.07 and .50. In order to induce an adequate yaw level the bourrelets were decreased in diameter to increase clearance with the rifling lands. This produced satisfactory yaw in most cases, in the order of one to three degrees.

Due to the rapid variation of the aerodynamic properties of the shell with Mach number and nonlinear variation with yaw level the data from the greater part of the rounds could not be reduced accurately for the whole range traversed by a round. Therefore the data from each single round was divided, and data from each of the two parts of the measured trajectory was treated as a separate round. The data thus treated provided sufficiently accurate aerodynamic coefficients.[2,3]

* Some specific information of interest to those concerned with the 57mm PAT system, i.e., charge-velocity, charge-pressure, spin and accuracy, are given in the appendix.

** Superscripts refer to reference numbers.

DRAG DATA

As is well known a dual flow phenomenon can occur about the front of a spike-nosed shell at supersonic velocities[4,5]. From the data for the T188 (Figure 3) it can be seen that a somewhat similar phenomenon occurs in the transonic region, although the difference between the two flow states is not as well defined. Inspection of the photographs, Fig. 10 through Fig. 13 shows the correlation between the flow about the front of the shell and the magnitude of the drag. The flow about the nose of the higher drag rounds separates at the tip of the spike but impinges on the shoulder, while the flow about the lower drag rounds passes the shoulder without striking it. Few rounds appeared to travel through the entire range without having the flow strike the shoulder during some part of the flight, thus the points are scattered rather than being in two distinct bands.

In spite of the large variation in the drag of the shell, the yaw drag coefficient, which is defined as $K_D = K_{D_0} + K_{D_{\delta^2}} \overline{\delta^2}$ is nearly constant throughout the test mach number range from .5 to 1.07 and has a value of 10 per radian squared.

OTHER COEFFICIENTS

The other aerodynamic coefficients also show an erratic tendency. By inspection of the mosaic photograph in Fig. 14 and other photographs, the entire shell, and particularly the tail, can be seen to be shrouded in heavy turbulence so that the shell may yaw several degrees before the tail fins enter the undisturbed flow. This turbulence and the external shock waves, both transient and fixed, contribute to a very erratic performance.

K_M, RIGHTING MOMENT COEFFICIENT

Inspection of Figure 4, K_M versus Mach number, indicated the large uncertainty in K_M at transonic velocities. Considerable light can be shed on the reason for this uncertainty by consideration of Figure 8 where K_M is plotted against Mach number with yaw level as a parameter.

In Figure 5 the data points have been separated into three yaw levels, giving three bands of K_M. As might be expected the curve for the rounds with the smallest yaw level shows the sharpest break and largest variation. The curve for the largest yaw level is least sensitive to Mach number variation.

There is apparently a weak correlation between the scatter in K_D and the scatter in K_M, with the higher drag rounds lying high in the particular yaw level band, the lower drag rounds lying low in the yaw level band.

K_H - K_{MA} DAMPING MOMENT COEFFICIENT

The aerodynamic coefficient which seems most affected by the [illegible] turbulence about the tail of the shell is the damping moment coefficient. The band of values which represents $K_H - K_{MA}$ are included in Figure 6 to show the character of the scatter and to indicate the nonlinear behavior of K_H. Figure 7, $K_H - K_{MA}$ versus M with $\overline{\delta^2}$ as a parameter, shows bands of values of $K_H - K_{MA}$ at three yaw levels.

K_N AND CP_N, NORMAL FORCE COEFFICIENT AND CENTER OF PRESSURE

Because of the very small amount of usable date obtained for K_N, and CP_N the scatter in the data completely obscures any trend. The data which had acceptable accuracy are plotted in Figures 8 and 9. Both K_N and CP_N apparently vary simultaneously with variation in flow pattern, Mach number, and yaw level in an undetermined manner.

CONCLUSIONS

The spike-nosed shell of which the 57-mm T188E18 is a representative sample, are being used fairly extensively in an anti-tank role. Such configurations have certain inherent advantages. They can be made relatively compact because the spike-nosed body has relatively small lift and hence weak destabilizing moment. Therefore, the stabilizing tail could be brought in close to the shell body. The spike-nosed shell launches better than more conventional shell because of its lower sensitivity to muzzle disturbances. Hence, at short ranges where the

accuracy is dominated primarily by the launching conditions, such shell should be more accurate. However, at longer ranges the unpredictable aerodynamic characteristics of spike-nosed shell are likely to cause lower accuracy even from drag variations alone. In this connection it should be noted that on a certain spike-nosed shell it became necessary to stabilize the flow over the spike by a special device in order to maintain the accuracy at 2000 yards comparable to that achieved at 1000 yards. Thus, even at such relatively short ranges the unpredictable behavior of the drag manifested itself in a deterioration of the accuracy.

At longer ranges and high angles of fire, other aerodynamic forces and moments enter into play and their equally unpredictable behavior is likely to aggravate the accuracy still further. Therefore, this use of such configurations at longer ranges probably will be unsatisfactory.

C. P. SABIN
SP-3

REFERENCES

1. Rogers, W. K. "The Transonic Free Flight Range," BRL Report No. 849 (Feb. 1953).
2. Murphy, C. H. "Date Reduction for the Free Flight Spark Ranges," BRL Report No. 900, (1954).
3. Murphy, C. H. "The Measurement of Non-Linear Forces and Moments by Means of Free Flight Tests", BRL Report No. 974, (Feb. 1956).
4. Karpov, B. G., and Piddington, M.J. "Effect on the Drag of Two Stable Flow Configurations over the Nose Spike of the 90-mm T316 Projectile", BRL TN 955, (C) (Oct. 1954).
5. Piddington, M. J. "Some Aerodynamic Properties of two 90-mm Spike-nose Shell T300E53 and T316E6", BRLM 1082, (July 1957).

TABLE I

DRAG DATA FOR T188

RD. NO.	M	$\overline{\delta^2}$*	K_{D_0}	RD. NO.	M	$\overline{\delta^2}$*	K_{D_0}
4040	1.066	1.08	.2756	4054	.872	.52	.1840
4037	1.060	.50	.2844	4061	.867	4.6	.1855
4036	1.053	.3	.2904	4055	.864	.36	.1855
4039	1.043	6.44	.2735	4056	.862	.4	.1800
4038	1.032	1.05	.2710	4061	.825	.5	.1831
4041	1.030	.3	.2807	4062	.818	1.00	.1800
4042	1.023	.2	.2675	4062	.786	.15	.1802
4049	1.023	2.67	.2769	4065	.764	3.19	.1844
4035	1.016	.4	.2643	4065	.727	.55	.1833
4043	1.014	.4	.2732	4064	.698	.7	.1882
4045	1.008	.1	.2705	4064	.670	.5	.1774
4030	1.008	.3	.2747	4066	.640	2.73	.1854
4044	1.008	1.2	.2701	4067	.634	3.22	.1930
4047	1.001	1.90	.2668	4066	.611	.64	.1860
4048	.999	6.48	.2636	4067	.604	.66	.1940
4040	.993	.13	.2440	4068	.546	2.6	.2043
4033	.990	2.30	.2570	4068	.524	1.5	.1977
4031	.987	.88	.2558	4069	.505	5.1	.2005
4037	.986	.09	.2424	4069	.496	3.0	.1965
4036	.978	.2	.2378				
4039	.974	.46	.2195				
4038	.966	.35	.2015				
4041	.963	.1	.2080				
4049	.958	.66	.2033				
4043	.952	.2	.1958				
4030	.951	.1	.2004				
4052	.950	5.10	.2007				
4045	.949	.1	.1973				
4031	.948	.38	.2068				
4044	.948	.4	.1973				
4047	.943	.56	.1972				
4048	.942	.84	.1976				
4033	.934	.01	.1992				
4046	.934						
4054	.923	2.40	.1963				
4032	.920	.2	.1874				
4026	.918	.2	.1921				
4029	.916	.5	.1956				
4028	.911	.3	.1930				
4070	.908	.8	.1909				
4053	.902	.6	.1916				
4052	.900	.94	.1897				

* Underlined $\overline{\delta^2}$ from split yaw reduction. Remainder evaluated by $\overline{\delta^2} = \frac{\sum(\delta_H^2 + \delta_V^2)}{n}$ where δ_H = yaw in horizontal plane; δ_V = yaw in vertical plane; n = number of stations.

TABLE II

OTHER AERODYNAMIC COEFFICIENTS

RD NO	M	K_M	K_H*	K_N	CP Cal fr Base	$\overline{\delta^2}$
4040	1.066	-2.50	27.4	1.43	3.17	1.08
4037	1.060	-2.25	--	1.61	3.52	.49
4039	1.043	-2.48	33.8	1.25	2.83	6.44
4038	1.032	-2.90	24.4	1.35	2.77	1.05
4049	1.023	-2.49	23.0	1.37	3.10	2.67
4035	1.019	-2.47	--	--	--	.32
4036	1.012	-2.88	--	--	--	.14
4047	1.001	-2.38	33.8	1.08	2.72	1.90
4048	.999	-2.56	29.8	1.14	2.68	6.48
4040	.993	-3.30	--	--	--	.13
4041	.992	-3.09	--	--	--	.16
4033	.990	-2.80	38.9	1.53	3.09	2.31
4042	.988	-3.08	--	--	--	.11
4031	.987	-2.75	--	--	--	.87
4043	.978	-3.08	--	--	--	.21
4039	.974	-3.50	23.6	--	--	.46
4044	.974	-2.99	19.0	--	--	.71
4030	.972	-3.17	--	--	--	.17
4038	.966	-4.09	--	--	--	.34
4049	.958	-3.05	27.9	--	--	.62
4046	.955	-3.40	--	--	--	.29
4052	.950	-3.12	22.7	1.12	2.13	5.10
4031	.948	-2.87	--	--	--	.38
4032	.944	-3.02	20.8	--	--	.80
4047	.943	-3.10	--	--	--	.56
4048	.942	-3.31	19.9	--	--	.84
4026	.940	-3.37	32.9	2.12	3.33	.40
4033	.934	-3.48	--	--	--	.09
4070	.929	-3.54	19.2	--	--	1.35
4053	.926	-3.04	--	--	--	.89
4054	.923	-3.02	16.1	1.23	2.46	2.40
4051	.913	-2.68	--	--	--	.81
4055	.909	-2.88	24.7	1.08	2.25	3.63
4052	.900	-2.66	17.7	--	--	.93
4059	.899	-2.84	25.2	--	--	2.25
4029	.893	-1.92	14.2	--	--	.25
4028	.888	-2.02	--	--	--	.14
4054	.873	-1.85	14.4	--	--	.52
4058	.871	-2.56	12.6	--	--	1.05
4055	.864	-2.27	--	--	--	.36
4061	.845	-2.57	25.6	.98	2.30	2.16
4060	.833	-2.73	36.0	--	--	.33
4056	.820	-2.34	--	--	--	.28
4062	.818	-2.44	31.0	--	--	1.00

* Only values with statistical errors less than 30% are listed.

TABLE II (Continued)

OTHER AERODYNAMIC COEFFICIENTS

RD NO	M	K_M	K_H*	K_N	CP Cal fr Base	$\overline{\delta^2}$
4062	.786	-2.62	--	--	--	.15
4065	.764	-2.62	23.0	1.64	3.32	3.19
4065	.727	-2.55	15.3	--	--	.55
4063	.727	-2.65	19.5	--	--	1.43
4064	.681	-2.75	--	--	--	.63
4066	.640	-2.68	19.2	1.12	2.52	2.73
4067	.634	-2.76	20.2	.94	1.87	3.22
4066	.611	-2.60	16.2	--	--	.64
4067	.604	-2.67	17.0	--	--	.65
4068	.531	-2.54	19.2	1.26	2.92	4.21
4069	.502	-2.33	24.4	1.02	2.64	4.74

APPENDIX

While the main purpose of the program was to determine the transonic properties of a spike nose shell, some information was obtained that may be of interest to people concerned with the 57-mm recoilless gun-shell system.

In these firings the T188 was fired from the M18 recoilless gun mounted in a Frankford rest (Figure 15). Five rounds were fired at normal velocity with spin-pins to determine the rate of roll. These rounds also were fired through a target card at 761 feet. Figure 16 shows the spin history of these rounds. An initial level of 1-1/2 to 2°/ft (0.005 to 0.006 rad/cal) is indicated. The spin tends to damp for most rounds although the failure to do so on one shell indicates considerably imperfect (or damaged) fins on this shell. These five shell gave a dispersion of 0.49 PE_H, 0.25 PE_V mils at 761 feet.

The remaining shell were fired at reduced velocities and the firing data may be useful. Figure 17 gives the charge-velocity data for the firings. The system has poor obturation as is indicated in Figure 18, a series of Fastax movie frames of a typical launch. A smear camera photograph (Figure 19) shows the shell still heavily enveloped by gases four feet from the muzzle.

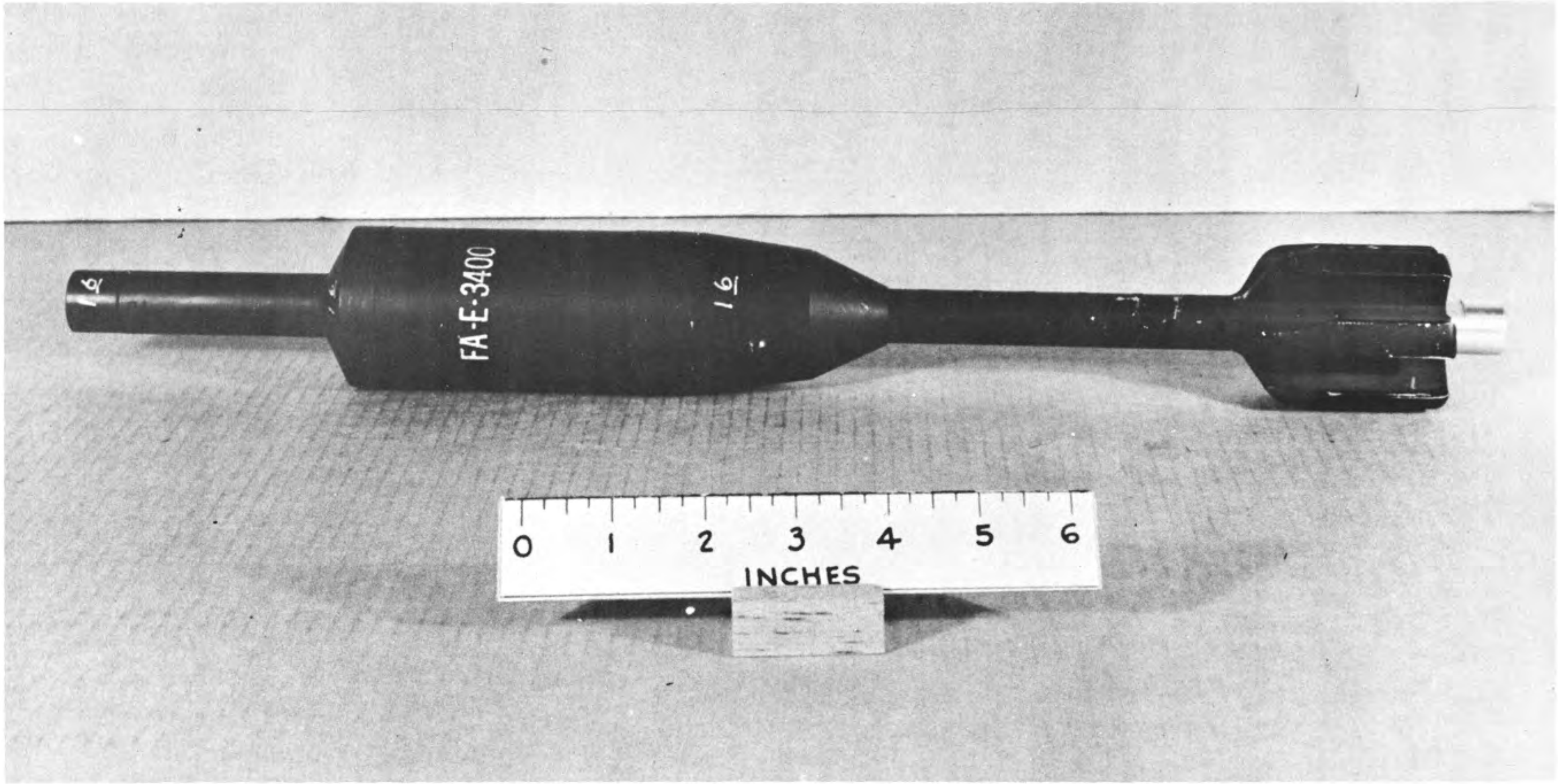
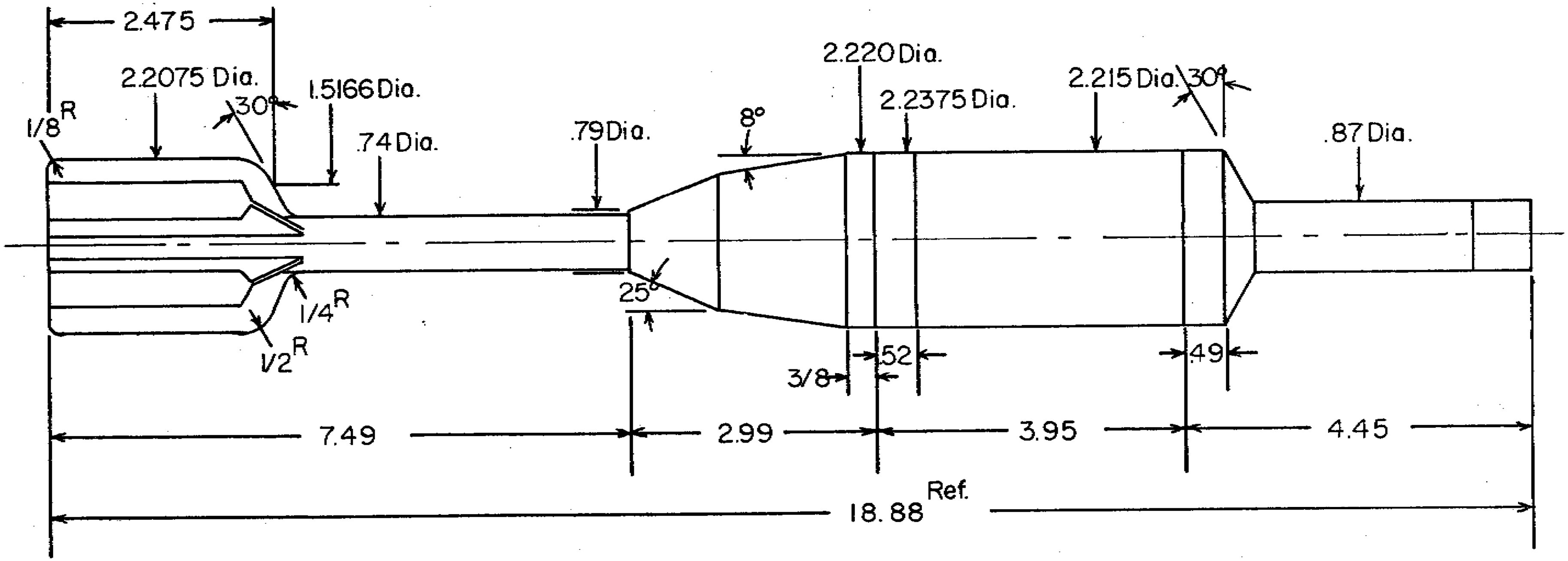


FIG. 1. 57mm T188E18 shell.

PROJECTILE, H.E.A.T., 57 mm T188E18, CONTOUR



NOTE: All Dimensions are in Inches

Weight	2.75 Lbs
C.G.	11.1 Inches from Base
A	1.62 Lb. in.^{2}
B	47.6 Lb. in.^{2}

FIGURE 2

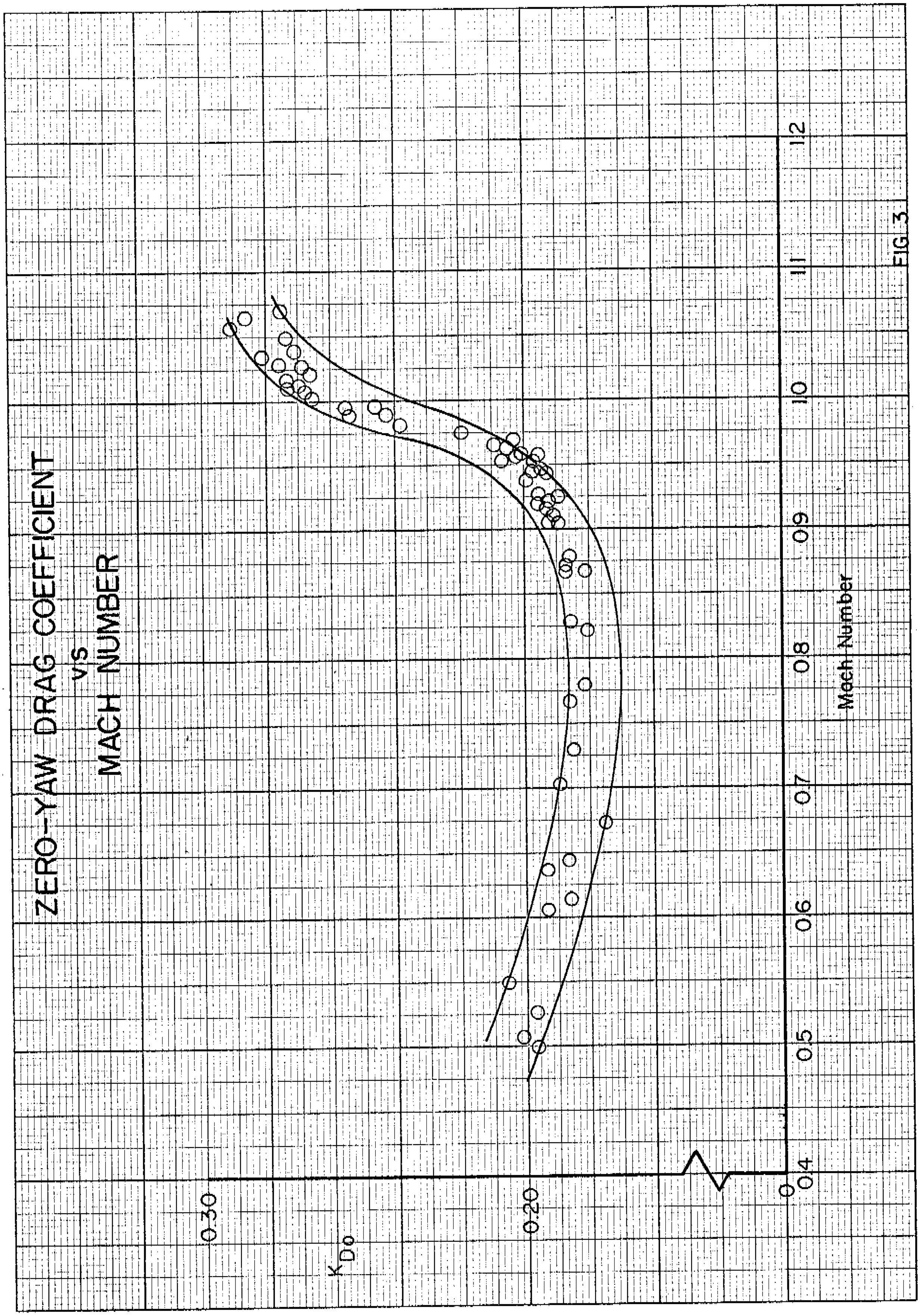

ZERO-YAW DRAG COEFFICIENT
vs
MACH NUMBER
K_{D_0}
0.30
0.20
0
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
Mach Number

FIG 3

RIGHTING MOMENT COEFFICIENT

VS

MACH NUMBER

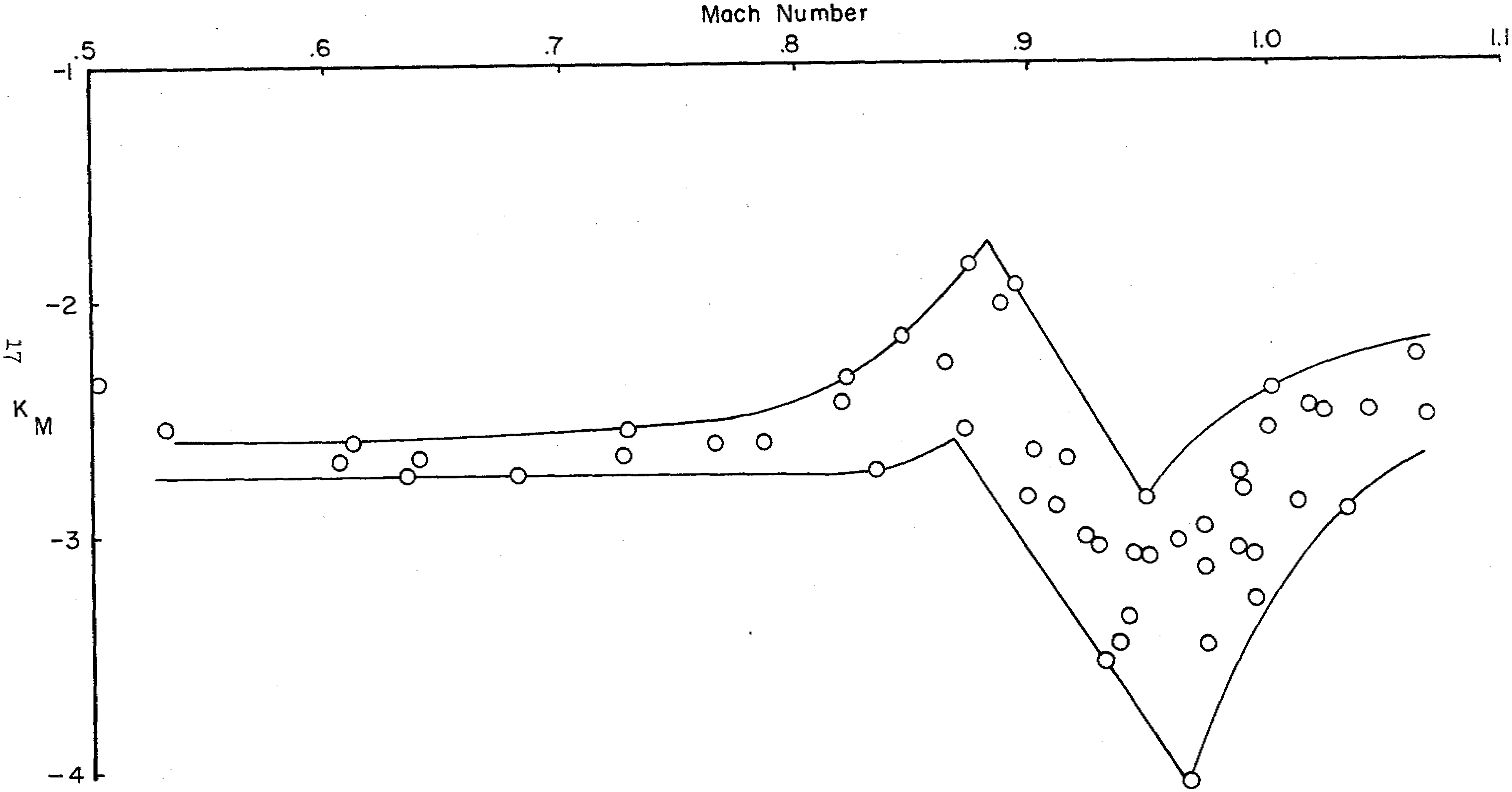


FIG. 4

RIGHTING MOMENT COEFFICIENT
vs
MACH NUMBER
PARAMETER: MEAN YAW SQUARED

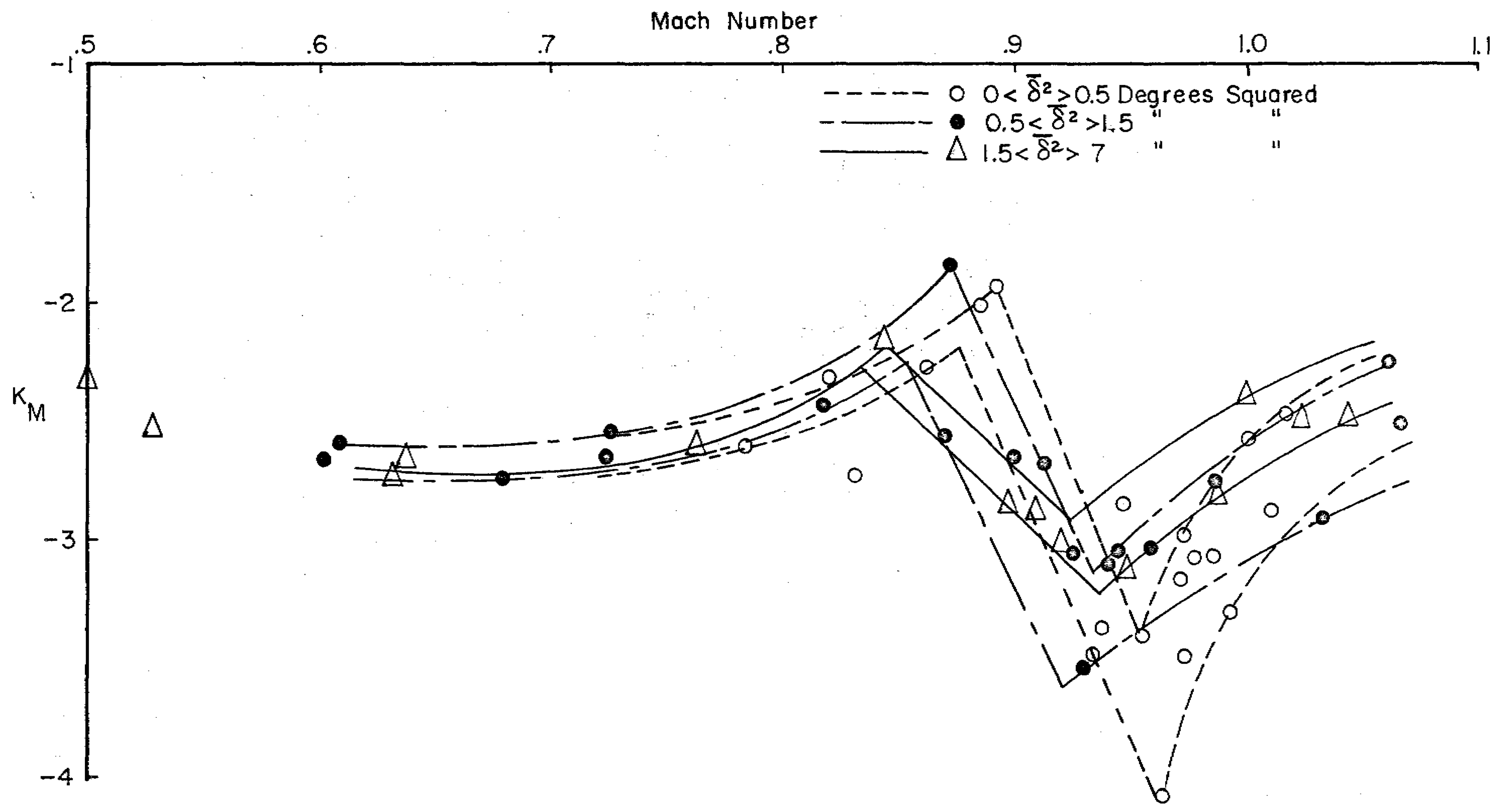


FIG. 5

DAMPING MOMENT COEFFICIENT
vs
MACH NUMBER

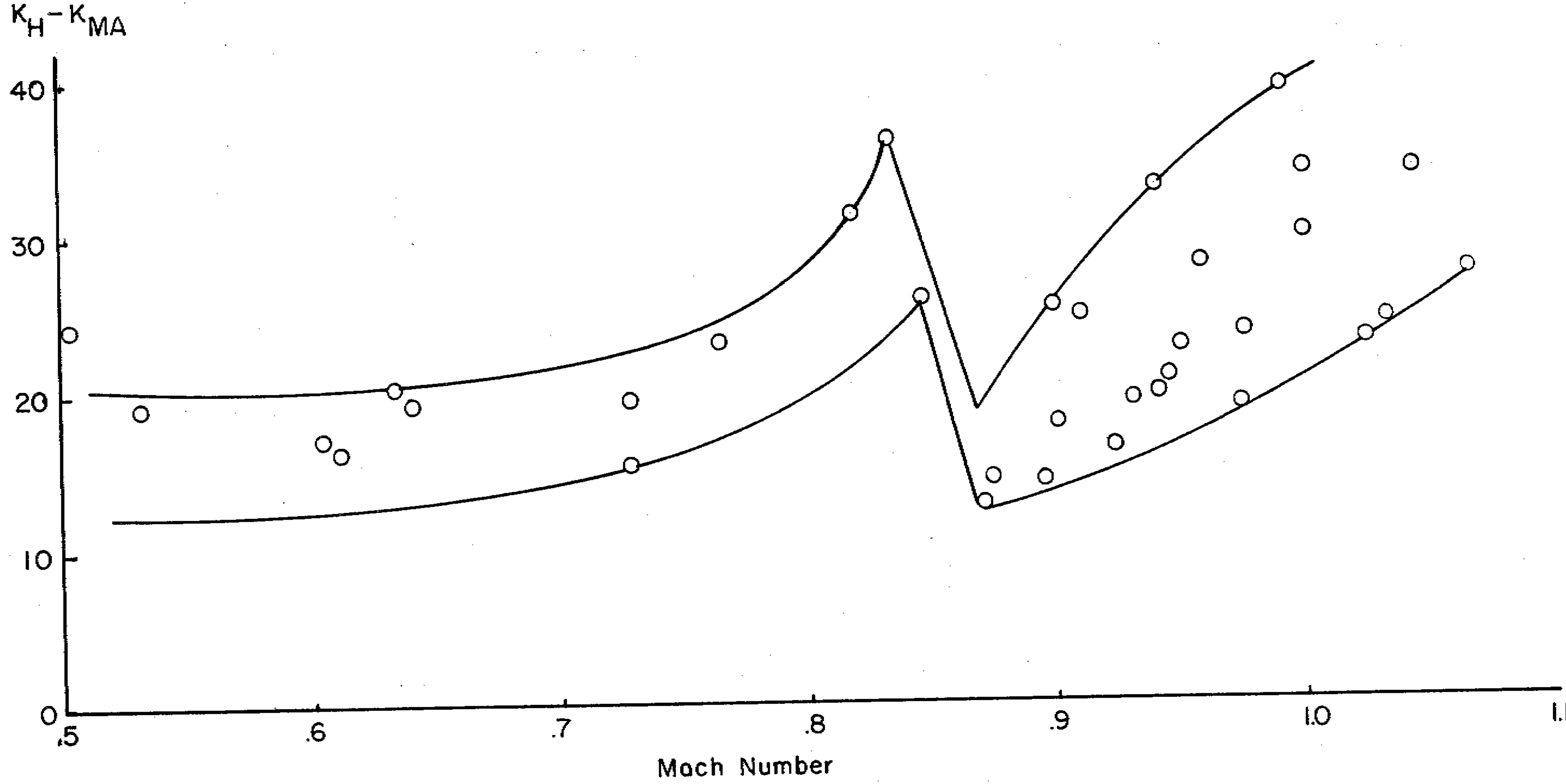


FIG. 6

DAMPING MOMENT COEFFICIENT
VS
MACH NUMBER
PARAMETER: MEAN YAW SQUARED

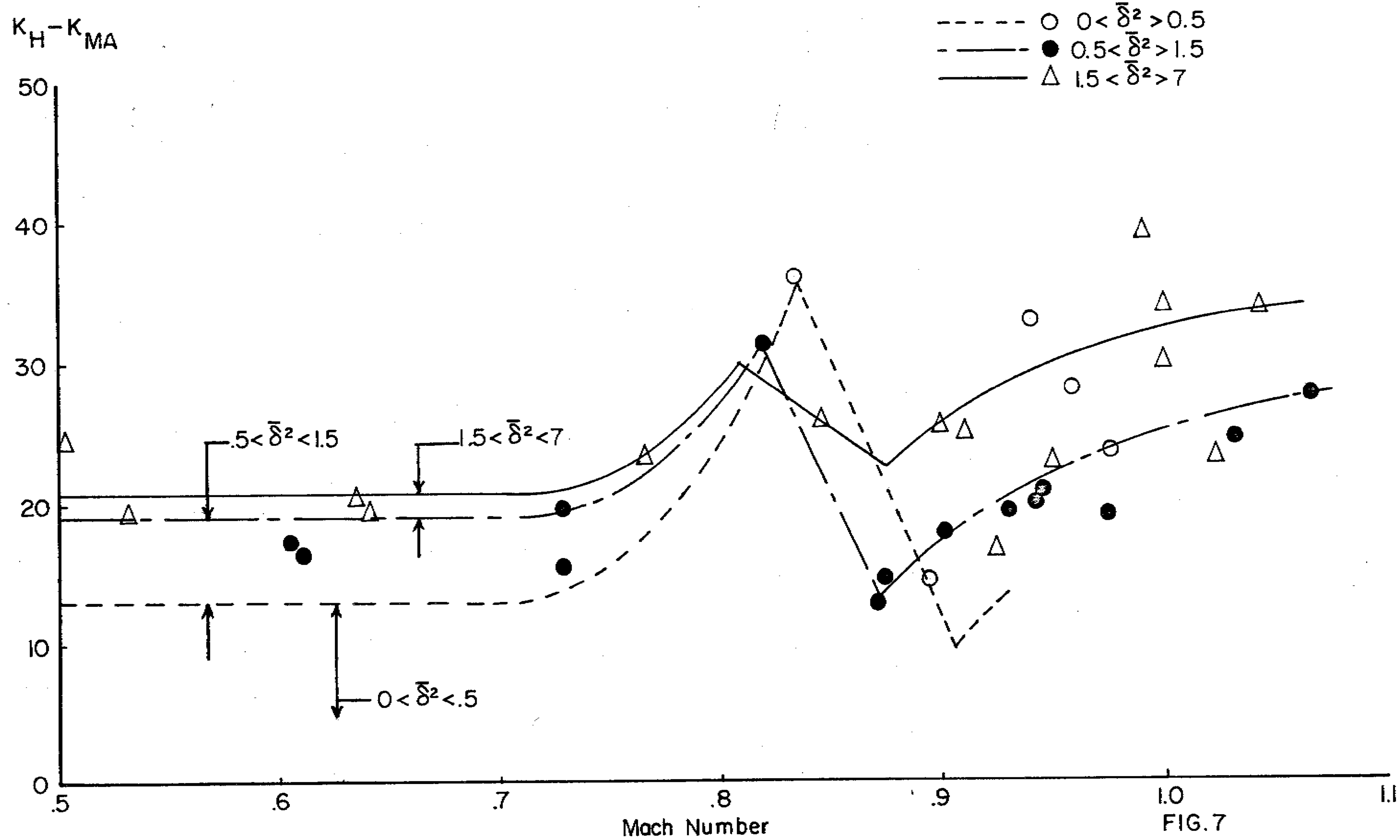


FIG. 7

NORMAL FORCE COEFFICIENT
vs
MACH NUMBER

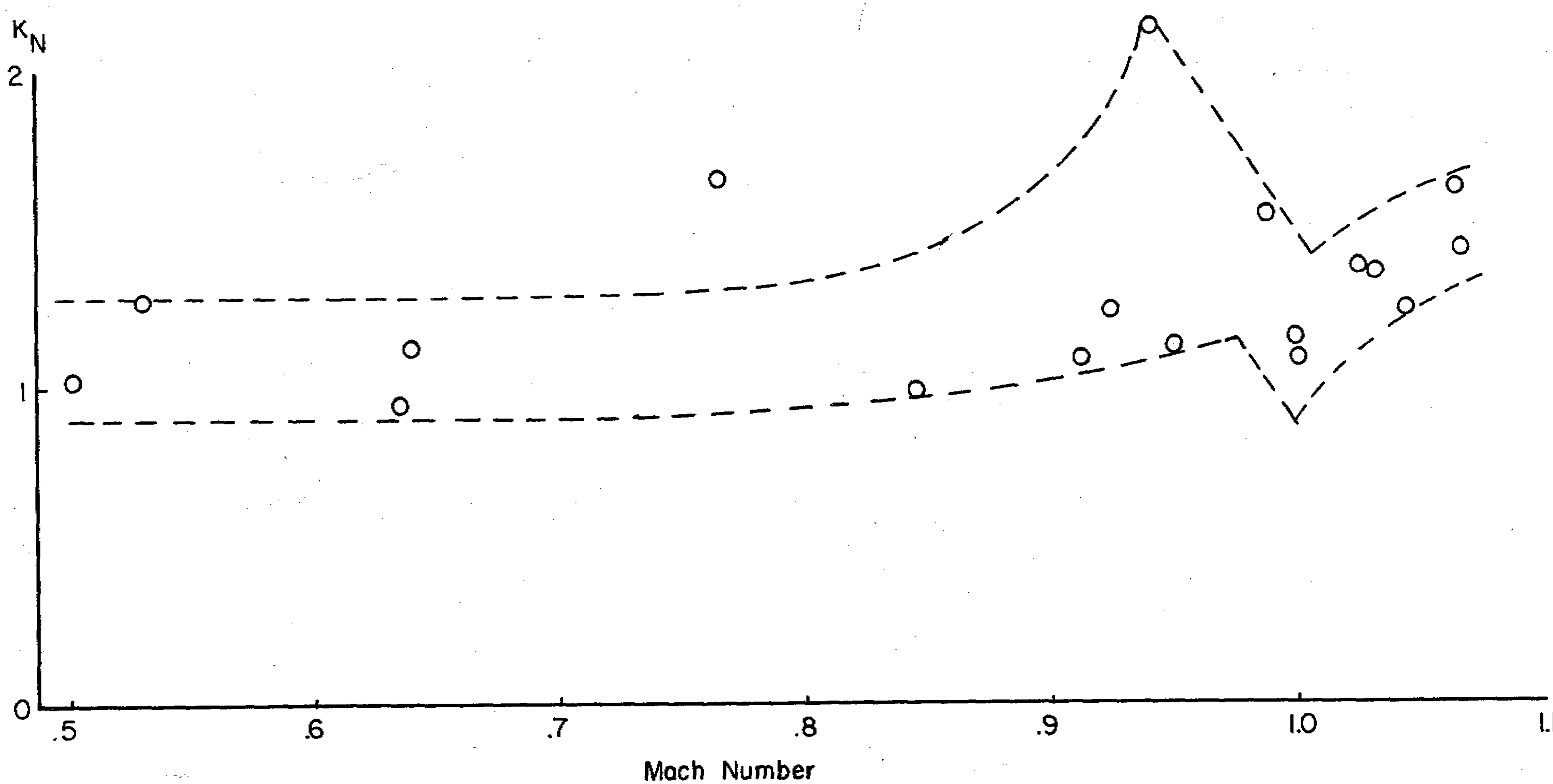


FIG. 8

CENTER OF PRESSURE OF NORMAL FORCE vs MACH NUMBER

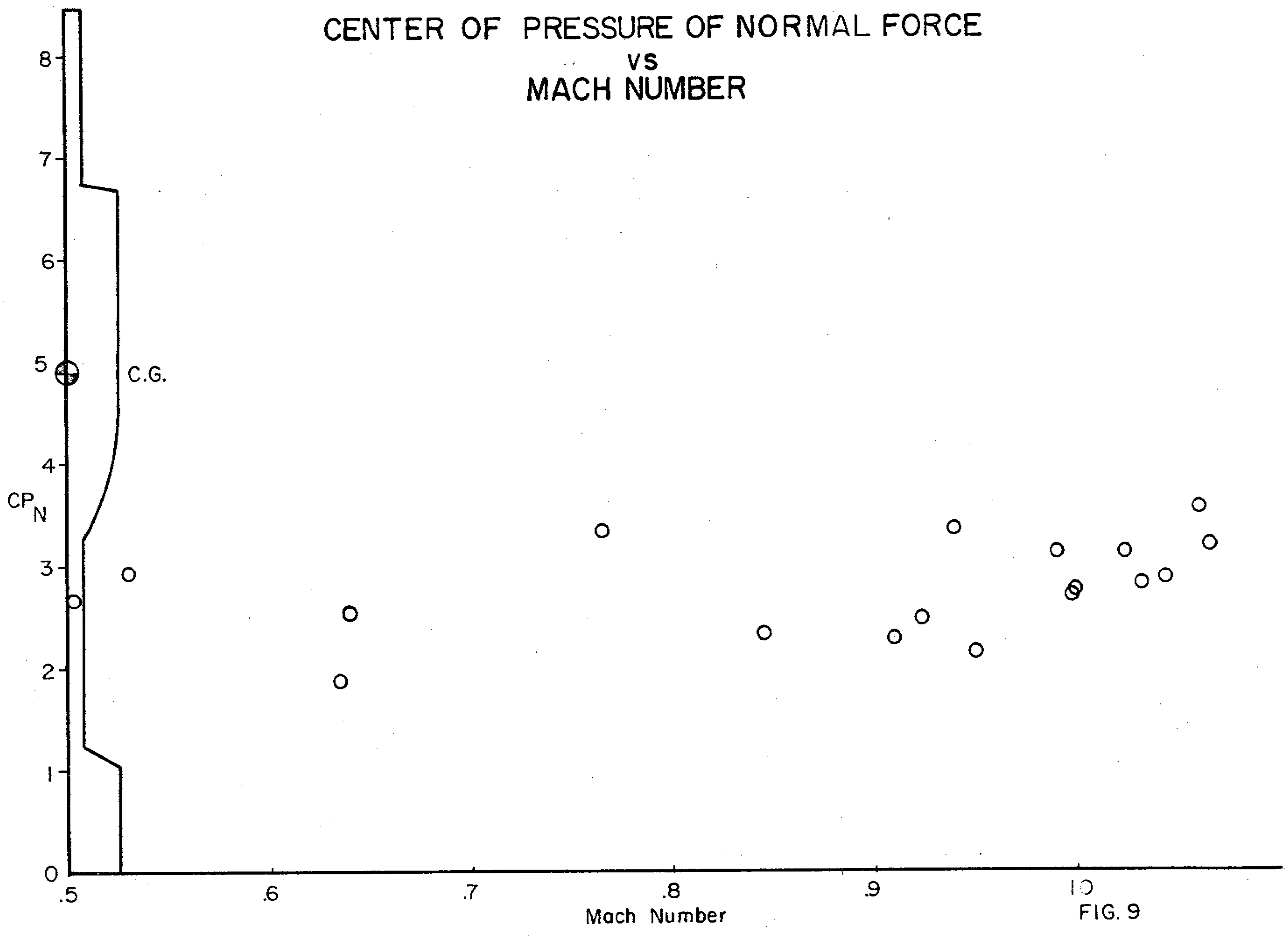


FIG. 9

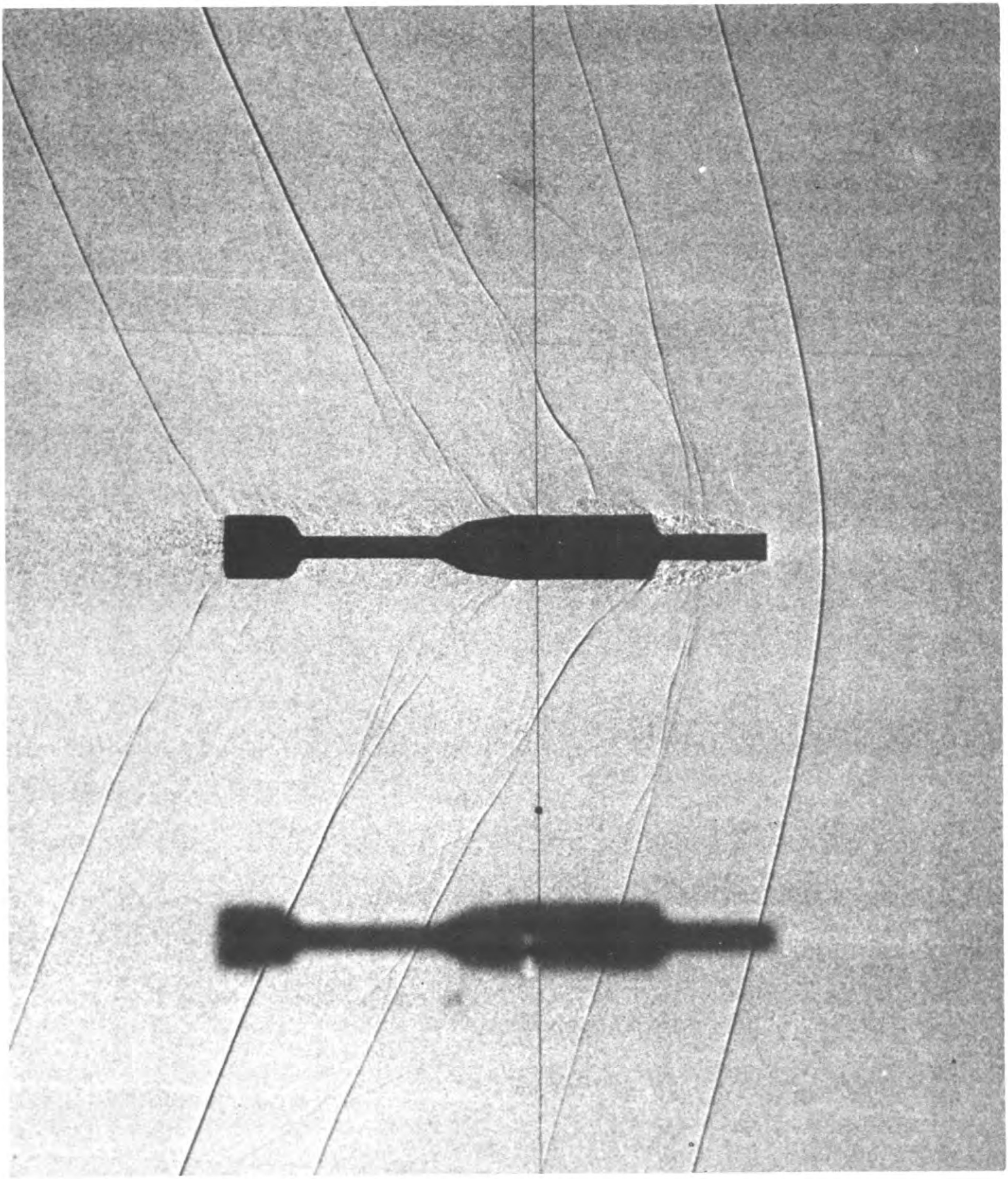


FIG. 10. Round 4037 M=1.06 high drag flow.

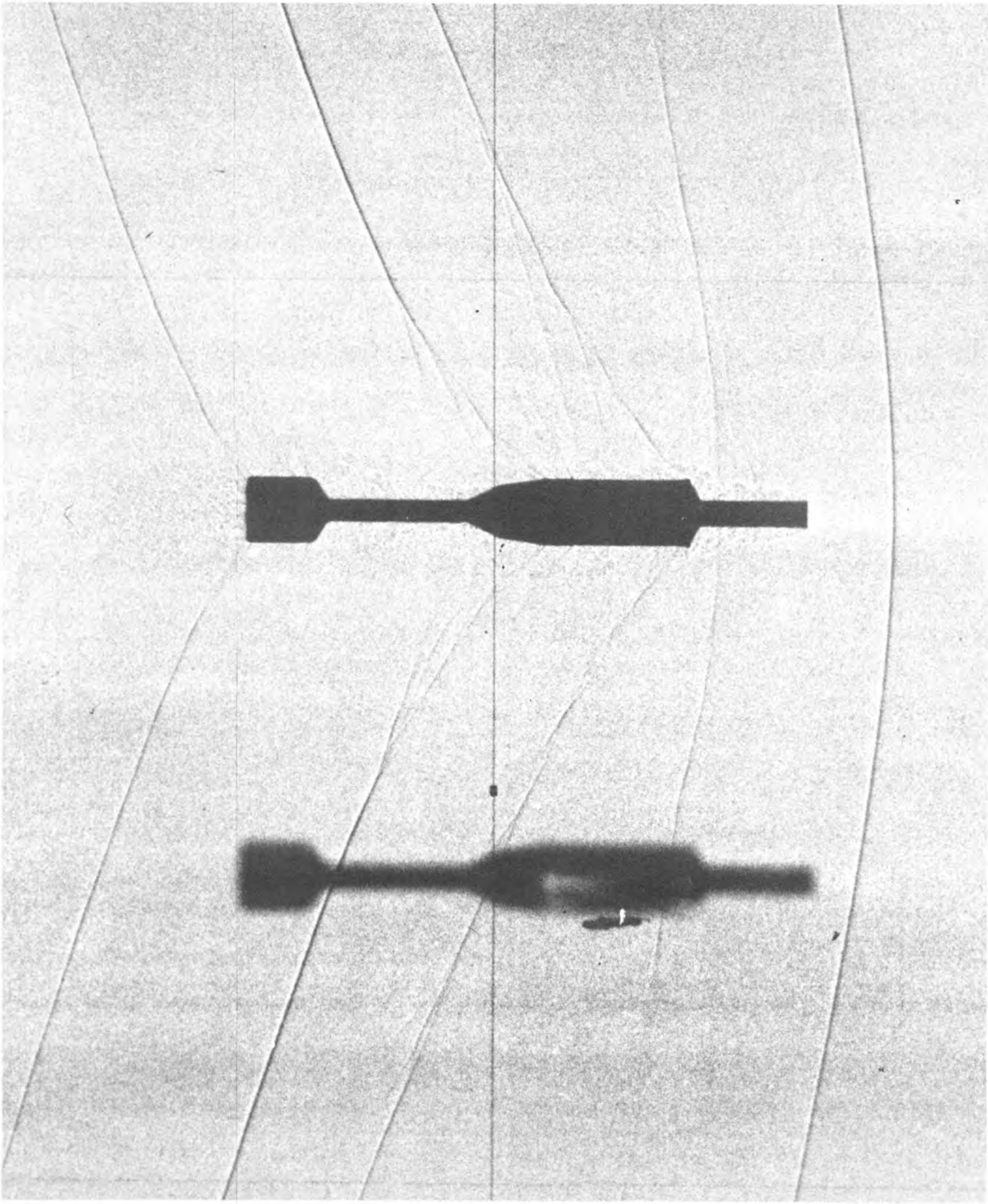


FIG. 11. Round 4038 M=1.032 low drag flow.

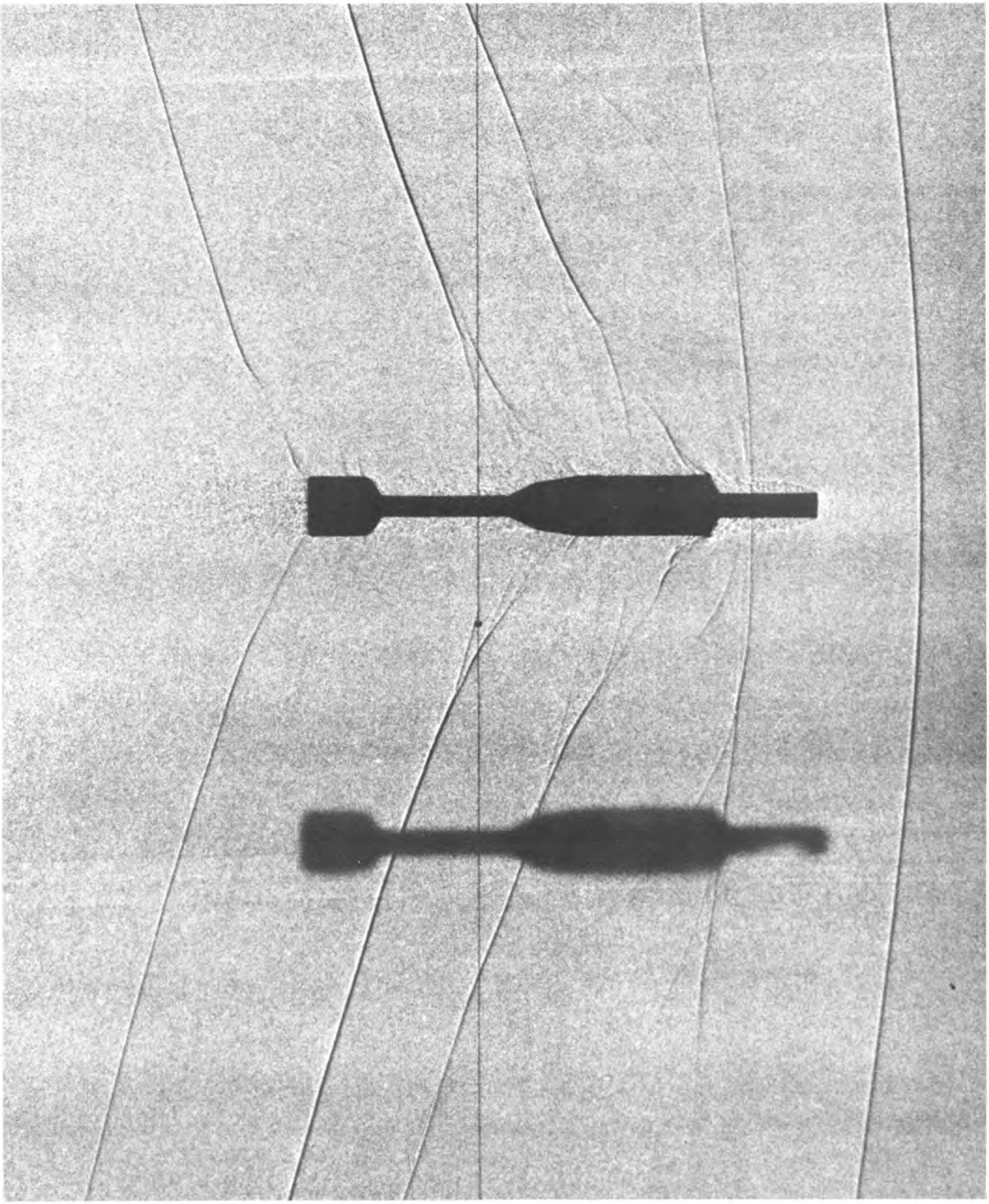


FIG. 12. Round 4041 M=1.03 high drag flow.

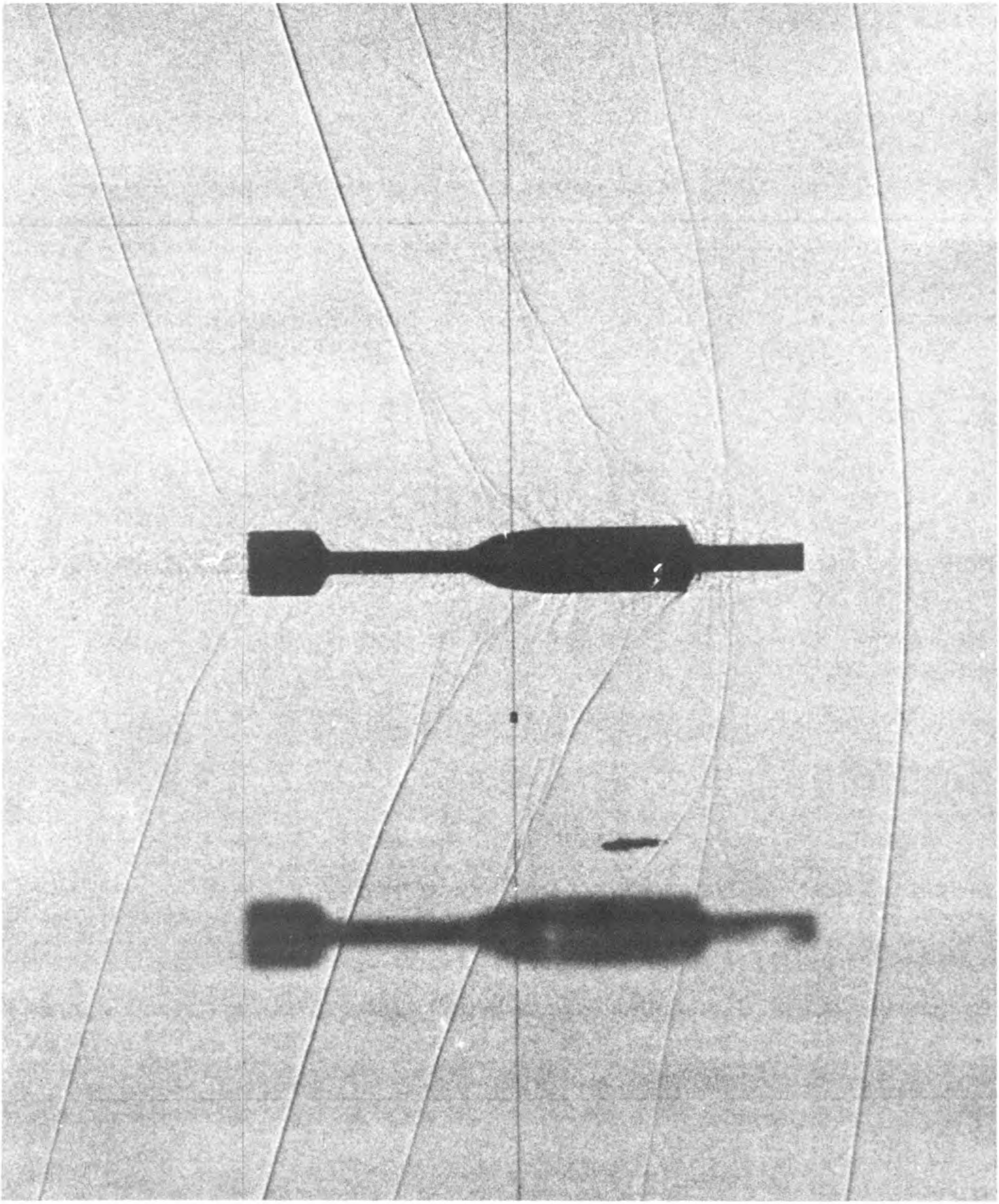


FIG. 13. Round 4042 M=1.02 low drag flow.

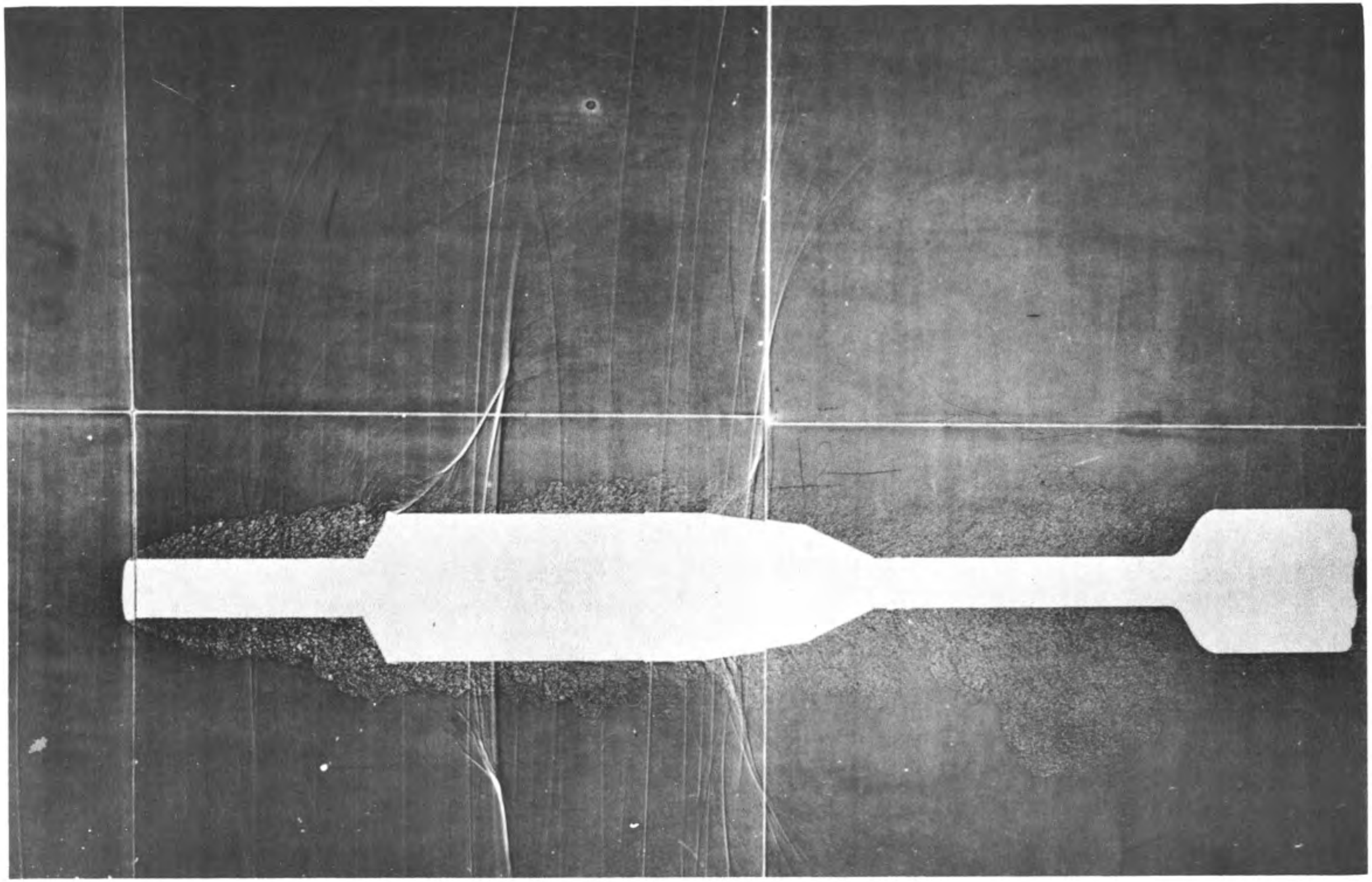


FIG. 14. Mossaic shadowgraph of T188 M=0.9.

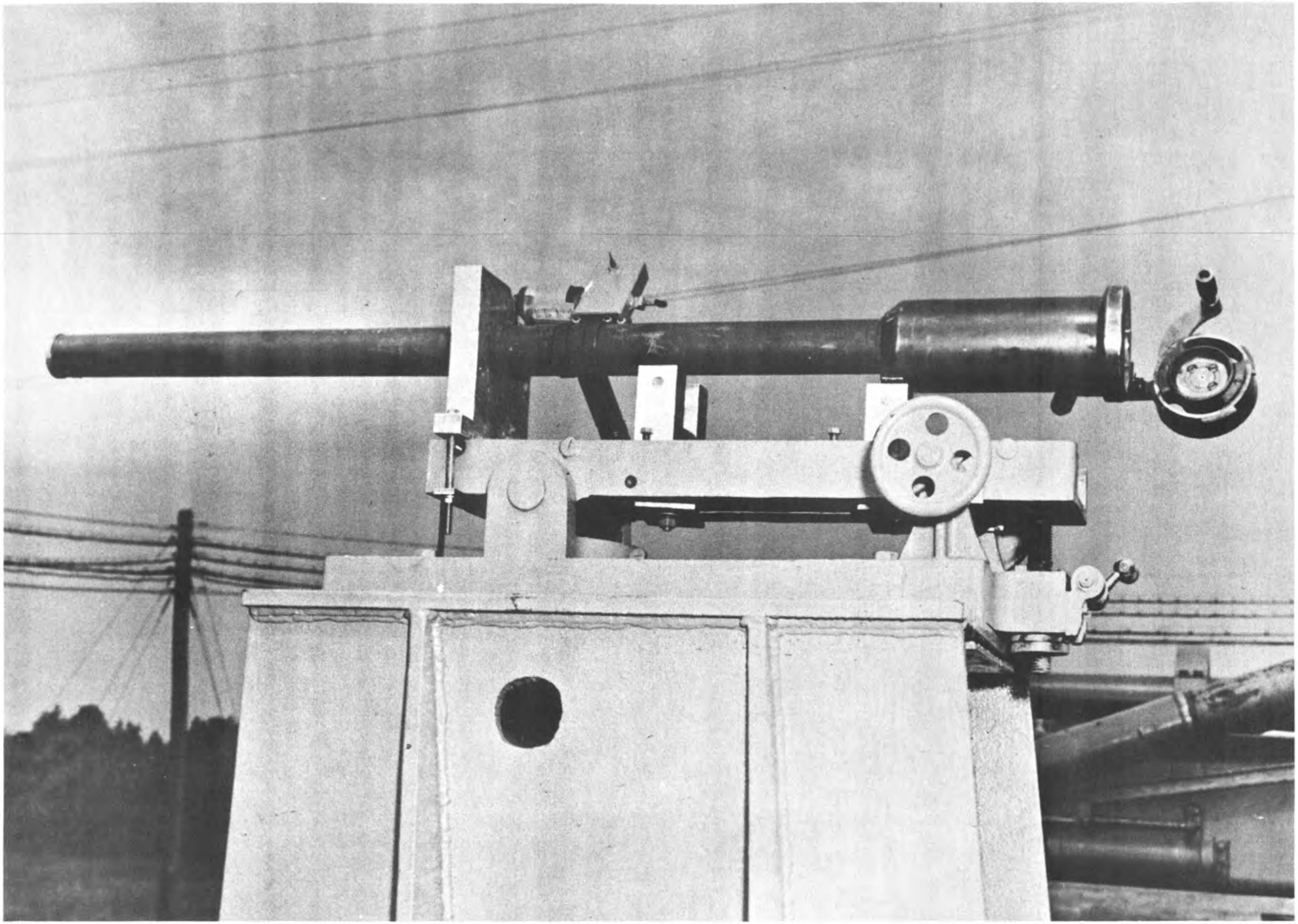
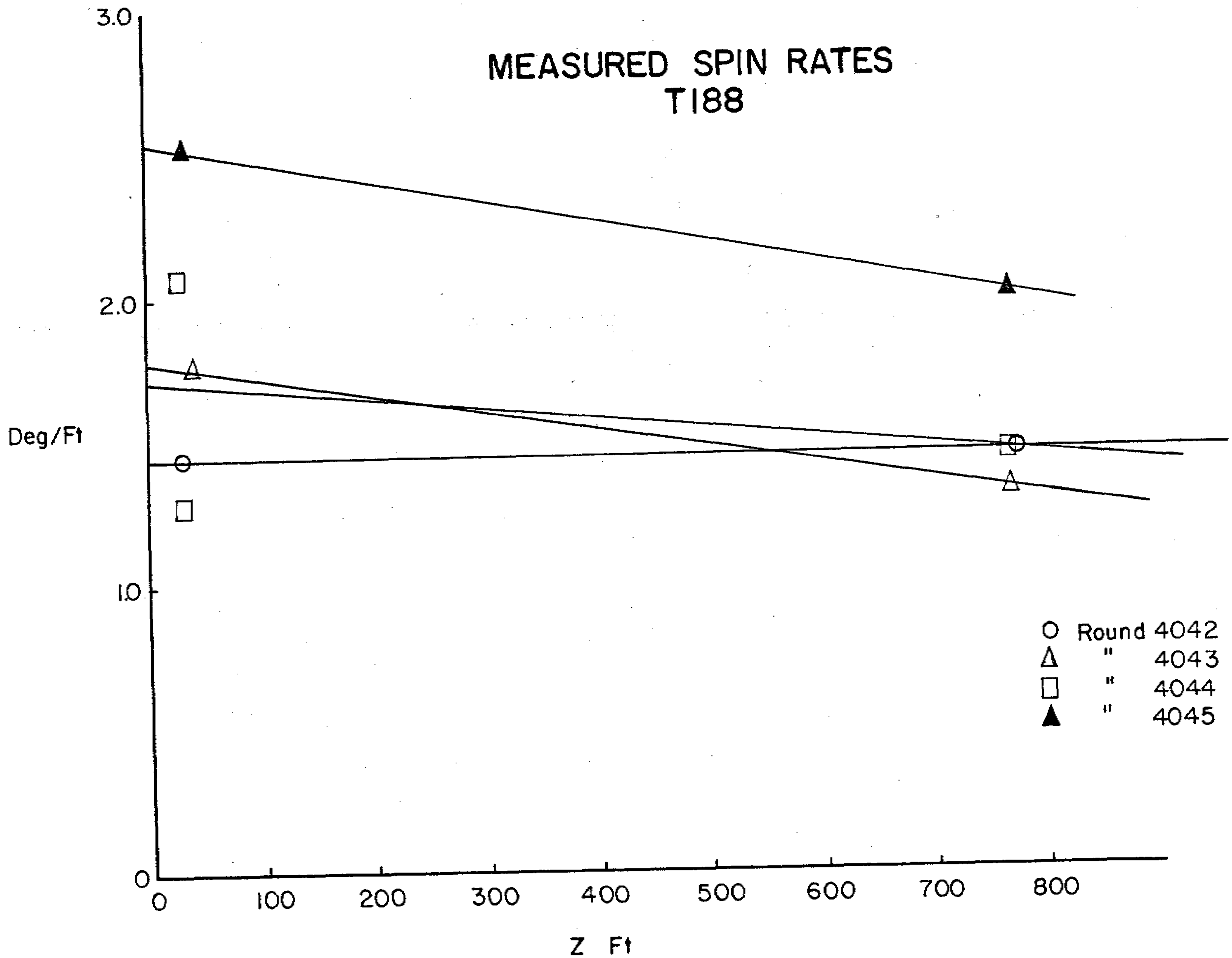


FIG. 15. M18 gun in Frankfort rest system.



MEASURED SPIN RATES
T188
Deg/Ft
3.0
2.0
1.0
0
0
100
200
300
400
500
600
700
800
Z Ft
Round 4042
" 4043
" 4044
" 4045

FIG. 16

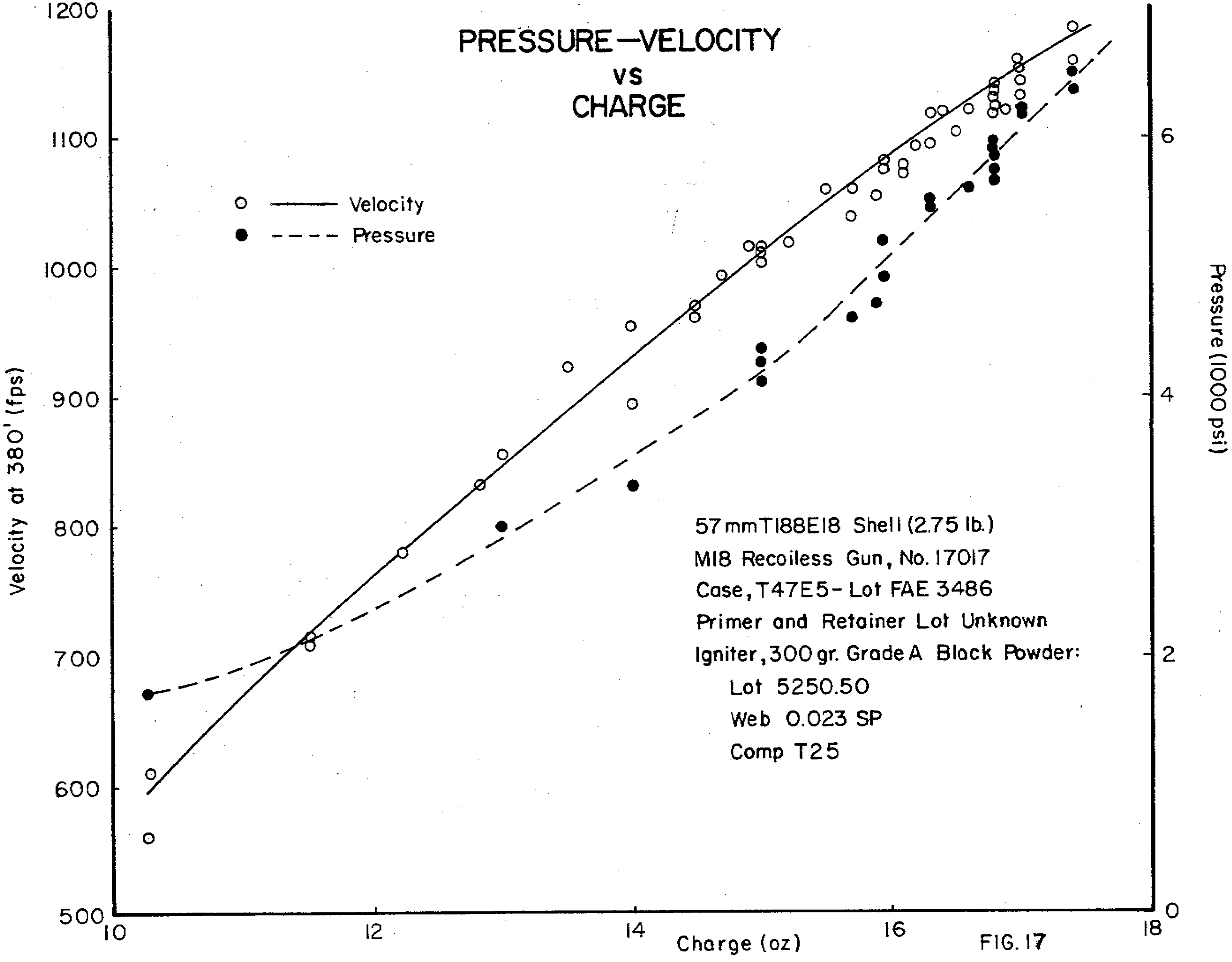

PRESSURE—VELOCITY
vs
CHARGE
Velocity
Pressure
57 mm T188E18 Shell (2.75 lb.)
M18 Recoilless Gun, No. 17017
Case, T47E5 - Lot FAE 3486
Primer and Retainer Lot Unknown
Igniter, 300 gr. Grade A Black Powder:
Lot 5250.50
Web 0.023 SP
Comp T25
Velocity at 380' (fps)
1200
1100
1000
900
800
700
600
500
Pressure (1000 psi)
6
4
2
0
Charge (oz)
10
12
14
16
18

FIG. 17

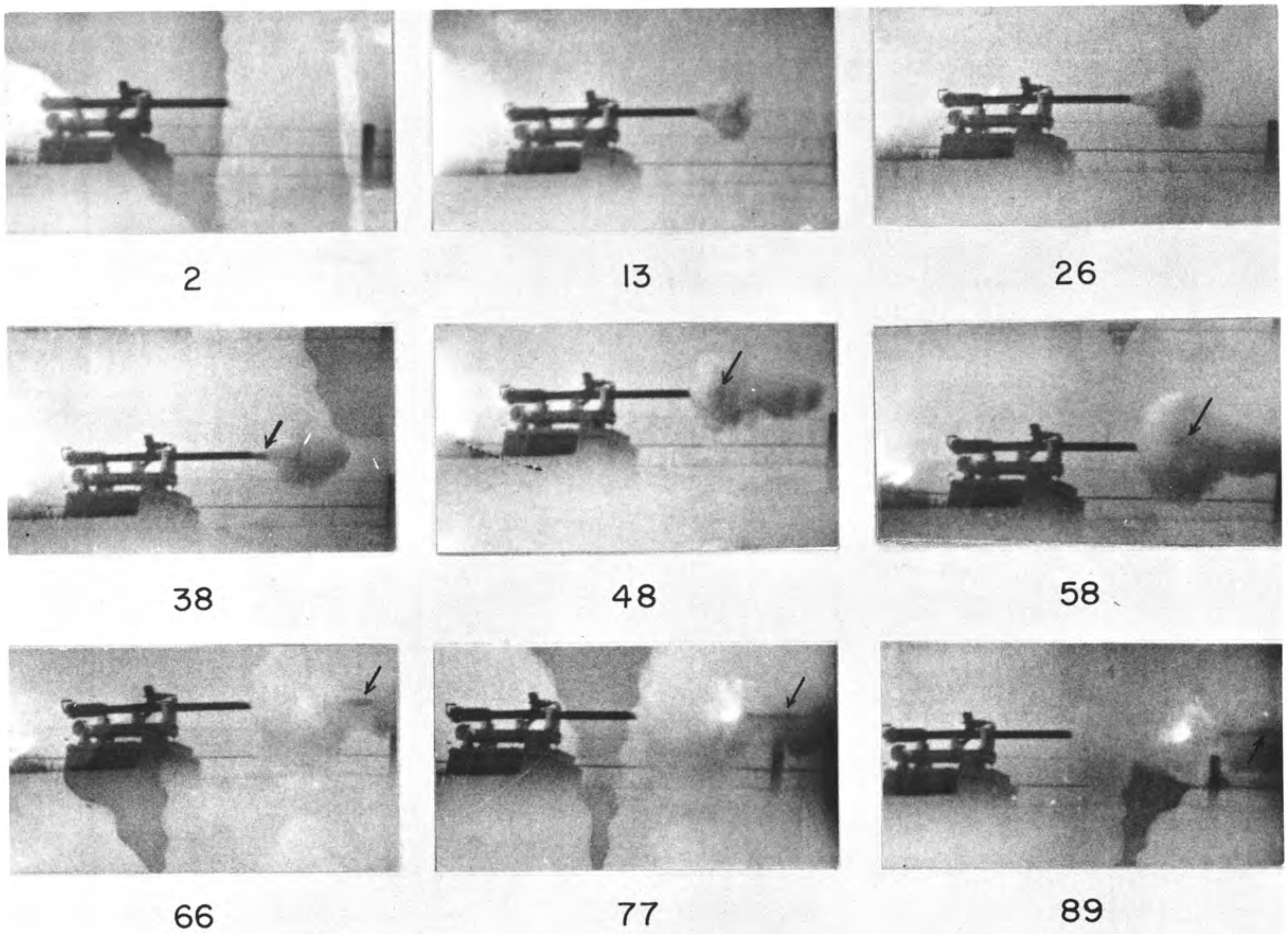


FIG. 18. Launching of 57 mm Shell T188 from M18 rifle. Number denotes frame number counting from first appearance of muzzle gas. The camera is operating at about 10,000 frames a second. Arrow denotes shell.

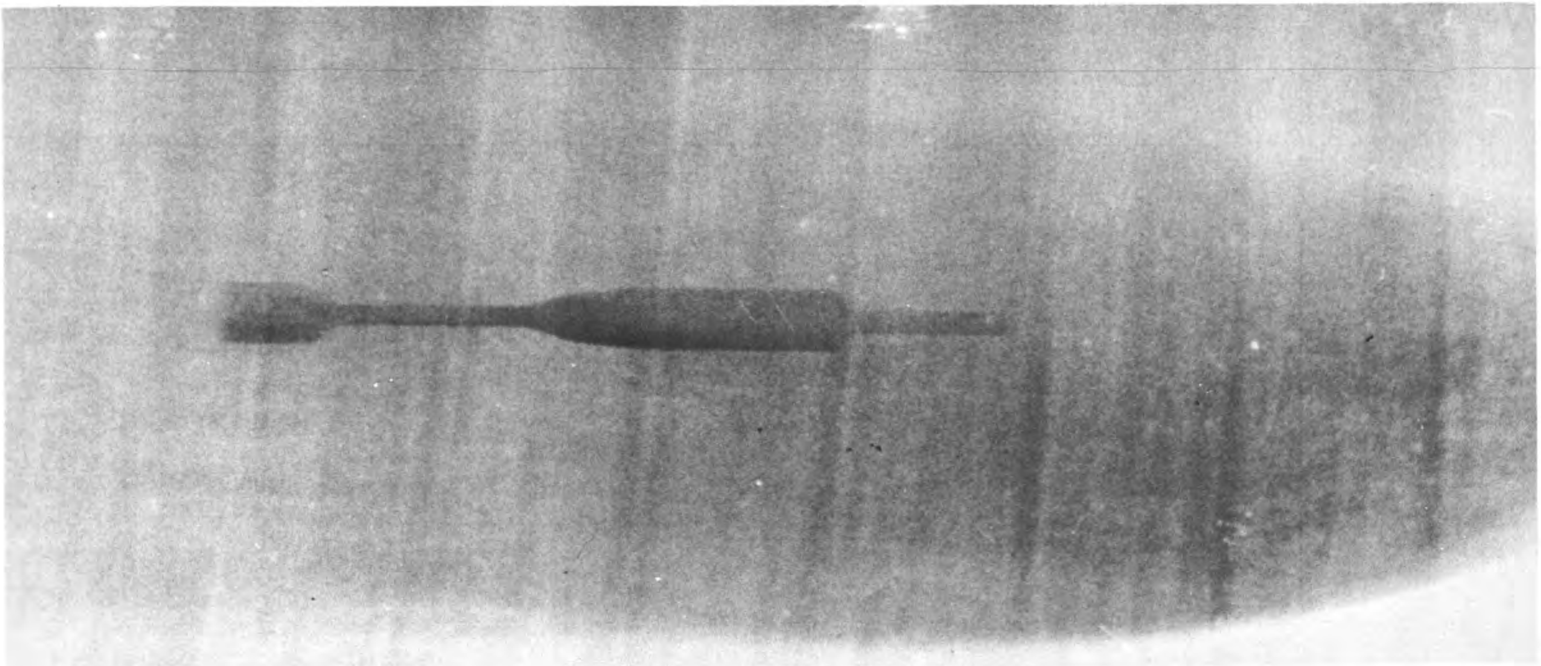


FIG. 19. Smear photograph of shell in gas four feet from muzzle.

DISTRIBUTION LIST

No. of Copies	Organization
1	Chief of Ordnance Department of the Army Washington 25, D. C. Attn: ORDTB - Bal Sec
10	British Joint Services Mission 1800 K Street, N. W. Washington 6, D. C. Attn: Mr. John Izzard Reports Officer
4	Canadian Army Staff 2450 Massachusetts Ave., N. W. Washington 8, D. C.
3	Chief, Bureau of Ordnance Department of the Navy Washington 25, D. C. Attn: ReO
2	Commander Naval Proving Ground Dahlgren, Virginia
1	Commander Naval Ordnance Laboratory White Oak Silver Spring, Maryland Attn: Mr. Witt
1	Superintendent Naval Postgraduate School Monterey, California
2	Commander Naval Air Missile Test Center Point Mugu, California
1	Commanding Officer and Director David W. Taylor Model Basin Washington 7, D. C. Attn: Aerodynamics Laboratory
1	Commander Naval Air Development Center Johnsville, Pennsylvania

No. of Copies	Organization
1	Commanding Officer Naval Air Rocket Test Station Lake Denmark Dover, New Jersey
3	Commander Naval Ordnance Test Station China Lake, California Attn: Technical Library (2 cys) Aeroballistic Lab. (1 cy) Code 5034
4	Commander Air Research and Development Command Andrews Air Force Base Washington 25, D. C. Attn: Deputy for Development
1	Commander Air Proving Ground Center Eglin Air Force Base Florida Attn: Armament Center (ACOT)
1	Commander Arnold Engineering Development Center Tullahoma, Tennessee Attn: Deputy Chief of Staff R&D
10	Director Armed Services Technical Information Agency Arlington Hall Station Arlington 12, Virginia
1	Director National Advisory Committee for Aeronautics 1512 H Street, N. W. Washington 25, D. C.

DISTRIBUTION LIST

No. of Copies	Organization
1	Director National Advisory Committee for Aeronautics Ames Laboratory Moffett Field, California Attn: Dr. A. C. Charters Mr. H. J. Allen
3	National Advisory Committee for Aeronautics Langley Memorial Aeronautical Laboratory Langley Field, Virginia Attn: Mr. J. Bird Mr. C. E. Brown Dr. Adolf Busemann
1	National Advisory Committee for Aeronautics Lewis Flight Propulsion Laboratory Cleveland Airport Cleveland, Ohio Attn: F. K. Moore
2	Commanding General U. S. Army Ordnance Arsenal Redstone Arsenal, Alabama Attn: Technical Library T. G. Reed, ABMA
3	Commanding Officer Picatinny Arsenal Dover, New Jersey Attn: Samuel Feltman Ammunition Labs.
2	Commanding General Frankford Arsenal Philadelphia 37, Pennsylvania Attn: Reports Group
1	Director, JPL Ord Corps Installation 4800 Oak Grove Drive Department of the Army Pasadena, California Attn: Mr. Irl E. Newlan Reports Group
1	Commanding Officer Chemical Warfare Laboratories Army Chemical Center, Maryland
1	Director, Operations Research Office 7100 Connecticut Avenue Chevy Chase, Maryland Washington 15, D. C.
1	Armour Research Foundation Illinois Institute of Technology Technology Center Chicago 16, Illinois Attn: Mr. W. Casier
2	Applied Physics Laboratory 8621 Georgia Avenue Silver Spring, Maryland Attn: Mr. George L. Seielstad
1	Aerophysics Development Corp. P. O. Box 657 Pacific Palisades, Calif. Attn: Dr. William Bollay
1	Cornell Aeronautical Lab., Inc. 4455 Genesee Street Buffalo, New York Attn: Miss Elma T. Evans Librarian
1	M. W. Kellogg Company Foot of Danforth Avenue Jersey City 3, New Jersey Attn: Miss E. M. Hedley
1	Professor George Carrier Division of Applied Sciences Harvard University Cambridge 38, Massachusetts

DISTRIBUTION LIST

No. of Copies	Organization
1	Dr. A. E. Puckett Hughes Aircraft Company Florence Avenue at Teal Street Culver City, California
1	Professor Clark B. Millikan Guggenheim Aeronautical Lab. California Institute of Technology Pasadena 4, California
1	Dr. L. H. Thomas Watson Scientific Computing Laboratory 612 West 116th Street New York 27, New York
1	Professor Francis H. Clauser Department of Aeronautics Johns Hopkins University Baltimore 18, Maryland
1	Chief of Staff U. S. Army The Pentagon Washington 25, D. C. Attn: Director/Developments
1	Assistant Secretary of Defense (R & E) The Pentagon Washington 25, D. C. Director/Ordnance
1	Commanding Officer Diamond and Fuze Laboratories Washington 25, D. C. Attn: ORDTL - 06.33

AD ______ Accession No. ______ UNCLASSIFIED

Aerodynamic Properties of a Spike-Nosed Shell

Ballistic Research Laboratories, APG
THE AERODYNAMIC PROPERTIES OF A SPIKE-NOSED SHELL AT TRANSONIC VELOCITIES-
C. P. Sabin

BRLM Report No. 1112, November 1957

DA Proj 5B03-04-002, ORD Proj TB3-0108
UNCLASSIFIED Report

The aerodynamic characteristics of the 57-mm T188E18, a spike-nosed recoilless rifle HEAT shell which is designed to operate at transonic and high subsonic velocities, are presented and discussed.

From the considerable scatter in the aerodynamic data it is concluded that performance of spike-nosed shell at these velocities is inherently erratic although satisfactory for medium and short ranges.

AD ______ Accession No. ______ UNCLASSIFIED

Aerodynamic Properties of a Spike-Nosed Shell

Ballistic Research Laboratories, APG
THE AERODYNAMIC PROPERTIES OF A SPIKE-NOSED SHELL AT TRANSONIC VELOCITIES-
C. P. Sabin

BRLM Report No. 1112, November 1957

DA Proj 5B03-04-002, ORD Proj TB3-0108
UNCLASSIFIED Report

The aerodynamic characteristics of the 57-mm T188E18, a spike-nosed recoilless rifle HEAT shell which is designed to operate at transonic and high subsonic velocities, are presented and discussed.

From the considerable scatter in the aerodynamic data it is concluded that performance of spike-nosed shell at these velocities is inherently erratic although satisfactory for medium and short ranges.

AD ______ Accession No. ______ UNCLASSIFIED

Aerodynamic Properties of a Spike-Nosed Shell

Ballistic Research Laboratories, APG
THE AERODYNAMIC PROPERTIES OF A SPIKE-NOSED SHELL AT TRANSONIC VELOCITIES-
C. P. Sabin

BRLM Report No. 1112, November 1957

DA Proj 5B03-04-002, ORD Proj TB3-0108
UNCLASSIFIED Report

The aerodynamic characteristics of the 57-mm T188E18, a spike-nosed recoilless rifle HEAT shell which is designed to operate at transonic and high subsonic velocities, are presented and discussed.

From the considerable scatter in the aerodynamic data it is concluded that performance of spike-nosed shell at these velocities is inherently erratic although satisfactory for medium and short ranges.

AD ______ Accession No. ______ UNCLASSIFIED

Aerodynamic Properties of a Spike-Nosed Shell

Ballistic Research Laboratories, APG
THE AERODYNAMIC PROPERTIES OF A SPIKE-NOSED SHELL AT TRANSONIC VELOCITIES-
C. P. Sabin

BRLM Report No. 1112, November 1957

DA Proj 5B03-04-002, ORD Proj TB3-0108
UNCLASSIFIED Report

The aerodynamic characteristics of the 57-mm T188E18, a spike-nosed recoilless rifle HEAT shell which is designed to operate at transonic and high subsonic velocities, are presented and discussed.

From the considerable scatter in the aerodynamic data it is concluded that performance of spike-nosed shell at these velocities is inherently erratic although satisfactory for medium and short ranges.